

Using Simulation to Optimize Ski Jump Ramp Profiles for STOVL Aircraft

Greg Imhof and Bill Schork

Naval Air Warfare Center/Aircraft Division

Air Vehicle Department

Patuxent River, MD

December 01, 1999

Abstract for AIAA Modeling and Simulation Technologies Conference

14-17 August 2000

Denver, Colorado

20000607 029

Using Simulation to Optimize Ski Jump Ramp Profiles for STOVL Aircraft

Introduction

Ramps have been used for many years aboard the Navy ships of many countries to reduce takeoff run distance and wind-over-deck (WOD) requirements, as well as to increase the aircraft takeoff gross weight capability over that of a flat deck carrier. Under the Joint Strike Fighter program, an effort has been funded to evaluate various ramp profiles and ramp performance optimization methodologies. Results of these evaluations will be used with an advanced STOVL aircraft to provide the maximum benefit to takeoff performance, while not becoming a design driver for landing gear or adversely affecting ship designs.

The Boeing AV-8B Harrier is a true STOVL aircraft, in that it routinely performs short takeoffs and vertical landings. This allows operations from ships not equipped with catapults or arresting gear and that are considerably smaller than the US large deck carriers. This unique capability is obtained through a group of variable angle nozzles for vectored lift and a reaction control system for stability and control, which uses engine bleed air to provide thrust through several small nozzles located on the aircraft.

Many foreign navies operate Harriers from ships equipped with smooth profile ramps. The US Navy has conducted many ship and shore-based tests of smooth and segmented (flat plate) ramp profiles over the years to demonstrate the performance advantages of a ramp-assisted takeoff. Much of this work serves as the basis for our research initiative.

Preliminary Work

The first step was to collect data from prior flight tests to validate the AV-8B landing gear model. The test data were incomplete because the test aircraft did not have sufficient instrumentation to measure gear/store loads and accelerations. Therefore, criteria were developed which enabled us to compare predicted gear load trends and instead of actual gear and structural loads.

Preliminary Criteria for Ramp Optimization

1. The landing gear shall not compress to full closure at any point during the takeoff. Harrier flight tests have been conducted to within $\frac{1}{2}$ inch of full closure with no adverse results.
2. Investigate a segmented ramp versus a smooth profile ramp, and how it could be used with the existing structural and operational requirements of the aircraft. If so, what is the maximum angle change between segments that can be tolerated by the aircraft and aircrew?
3. Resonance effects from segmented ramps on landing gear and wing mounted stores are unknown, and efforts should be taken to break up or reduce these loads.

Preliminary Results

Preliminary simulation runs have been completed. Test results indicate that the segmented ramp concept shows great promise and could allow ship designers options in building retractable or reconfigurable ramp designs for future STOVL capable ships. Segmented ramp takeoff performance is not diminished as compared with a smooth ramp. Initial results indicate that segmented ramp profiles can be modified to keep the gear loads well within their structural limits. Since the velocity of the aircraft remains fairly constant while it is on the ramp, an equally distributed (same length) segment pattern generates a recurring load on the landing gear at each joint. If the frequency of these inputs is close to the natural frequency of the gear, or transmitted through the aircraft structure to a wing store, a resonance condition could be excited. This will be investigated at in more detail in the coming months.

Preliminary Conclusions

The smooth and segmented ramp profiles have demonstrated significant performance gains over a field or flat deck ship takeoff. Work will continue over the next several months to expand and refine the optimization criteria and investigate various ramp profiles and quantify their benefit to aircraft performance.

| REPORT DOCUMENTATION PAGE | | | Form Approved OMB No. 0704-0188 | |
|---|-----------------------------|--|------------------------------------|--|
| <p>Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.</p> | | | | |
| 1. REPORT DATE | 2. REPORT TYPE Abstract | | 3. DATES COVERED | |
| 4. TITLE AND SUBTITLE Using Simulation to Optimize Ski Jump Ramp Profiles for STOVL Aircraft | | 5a. CONTRACT NUMBER | | |
| | | 5b. GRANT NUMBER | | |
| | | 5c. PROGRAM ELEMENT NUMBER | | |
| 6. AUTHOR(S) Gregory Imhof Bill Schork | | 5d. PROJECT NUMBER | | |
| | | 5e. TASK NUMBER | | |
| | | 5f. WORK UNIT NUMBER | | |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Air Warfare Center Aircraft Division 22347 Cedar Point Road, Unit #6 Patuxent River, Maryland 20670-1161 | | 8. PERFORMING ORGANIZATION REPORT NUMBER | | |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Naval Air Systems Command 47123 Buse Road Unit IPT Patuxent River, Maryland 20670-1547 | | 10. SPONSOR/MONITOR'S ACRONYM(S) | | |
| | | 11. SPONSOR/MONITOR'S REPORT NUMBER(S) | | |
| 12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited. | | | | |
| 13. SUPPLEMENTARY NOTES | | | | |
| 14. ABSTRACT Ramps have been used for many years aboard the Navy ships of many countries to reduce takeoff run distance and wind-over-deck (WOD) requirements, as well as to increase the aircraft takeoff gross weight capability over that of a flat deck carrier. Under the Joint Strike Fighter program, an effort has been funded to evaluate various ramp profiles and ramp performance optimization methodologies. Results of these evaluations will be used with an advanced STOVL aircraft to provide the maximum benefit to takeoff performance, while not becoming a design driver for landing gear of adversely affecting ship designs. | | | | |
| 15. SUBJECT TERMS | | | | |
| 16. SECURITY CLASSIFICATION OF: | | 17. LIMITATION OF ABSTRACT Unclassified | 18. NUMBER OF PAGES 2 | 19a. NAME OF RESPONSIBLE PERSON Gregory Imhof |
| a. REPORT Unclassified | b. ABSTRACT Unclassified | | | c. THIS PAGE Unclassified |

0704-0188
4

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39-18